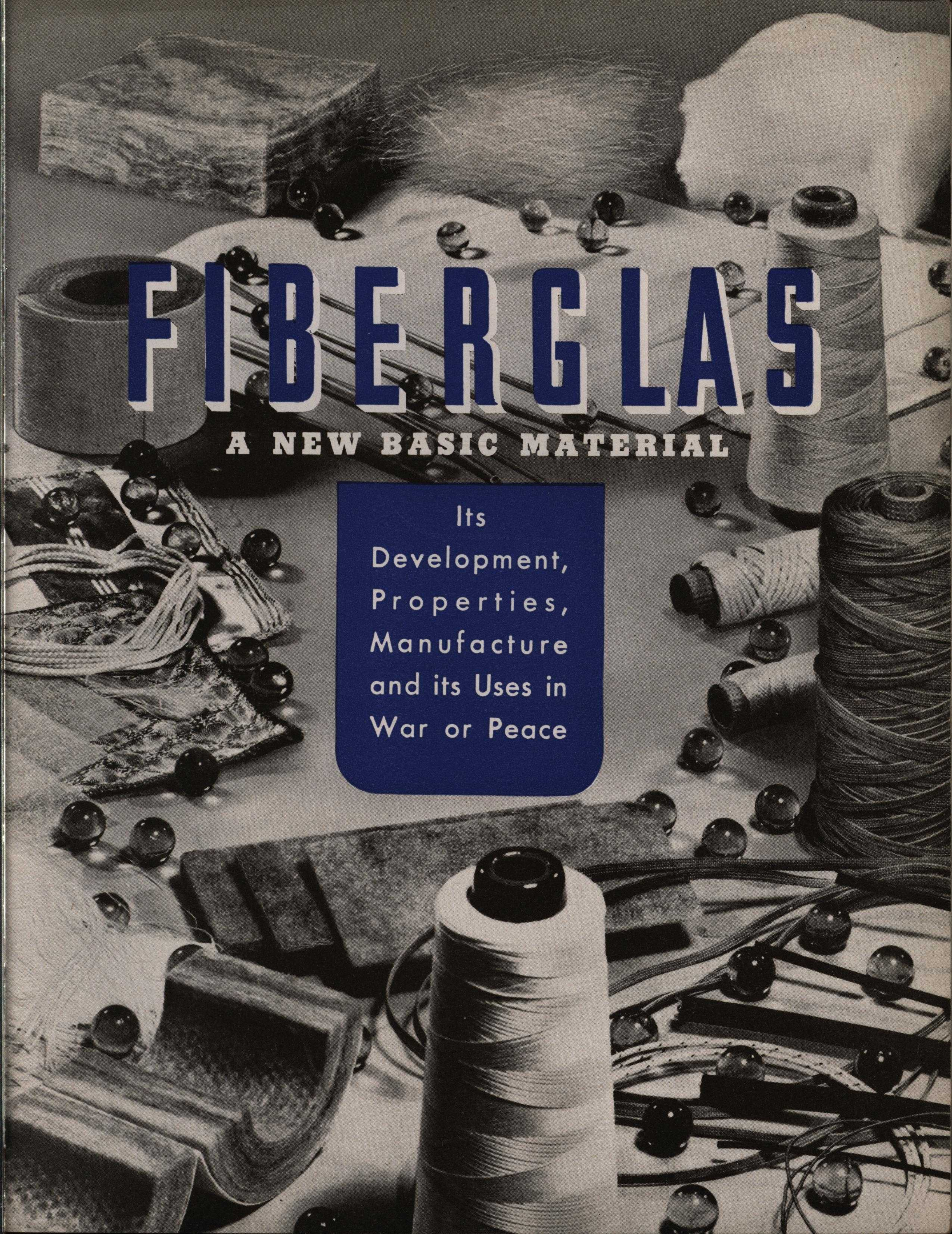
FIBERGLAS

A NEW BASIC MATERIAL

Its
Development,
Properties,
Manufacture
and its Uses in
War or Peace



DAY TANK OPERATOR—OWI PHOTO BY PALMER

Soldier of Production

GLASS that can be fabricated into resilient, wool-like bats or rigid, sawable boards, or that can be woven on a loom like cotton, silk or wool, seems—and is—a remarkable material.

It is as if we were suddenly able to breed pigs that sing and cows that roost in trees, so different are the properties of this glass—Fiberglas*—from those of glass in its traditionally hard, unbendable, transparent form.

Fiberglas is glass in the form of fine fibers or filaments. Because it is still a relatively new material, and because it is so different from the familiar conception of glass, and because it has found such widespread use, it is natural that many questions should be asked about its development, its properties, its uses and its manufacture.

In addition to thousands of questions from industry, these questions come from authors and publishers of text books, from editors of magazines and reference books, from lecturers, teachers and students, from writers preparing articles for technical magazines and other periodicals. It is to answer these questions that this booklet has been prepared.

Today, practically all Fiberglas materials, of all kinds, are furnished under Army, Navy or Maritime Commission specifications. Fiberglas is helping to give added stamina to the ships, tanks, planes and other weapons that American industry is producing for the battlefronts of the world.

A global war is spotlighting the manifold services this new kind of glass is able to perform, but the conception of Fiberglas as it serves today in its principal forms and applications, was clearly formed in the early 1930's. Throughout the decade before Pearl Harbor, Fiberglas had steadily been gaining recognition as a basic industrial material.

The word *basic* is the keynote here. It means that Fiberglas, like steel, or copper or aluminum, is a material that industry can employ in scores of different ways, for scores of different purposes, to produce scores of different products.

In a world at war these products range from insulating boards for the walls and roofs of plane assembly plants, to all-glass tape for filtering blood plasma; from mats that give added life to the storage batteries on which submarines operate, to shields for flares used to illuminate bombing objectives.

When the war is over, Fiberglas will return to its original role as a basic material of peace-time industry. In almost innumerable ways it will help improve man's machines and the environment in which he lives and labors.

**Fiberglas is the trade name {Reg. U. S. Pat. Off.} of glass manufactured in any fiber or filament form by Owens-Corning Fiberglas Corporation.*

The Search for a Pliable Glass

MEN have tried for centuries to make a pliable glass. They first dreamed of producing sheets or blocks of glass that would be unbreakable, and that could be shaped into desired forms.

A Roman is said to have discovered the secret, and to have presented his emperor with a vase made of this new kind of glass. His reward was to have his head chopped off so that the emperor alone might possess so rare an object.

This story may be legend, but the Venetians did learn how to draw glass into hair-like strands possessing some degree of flexibility. These strands they used to decorate their glassware. They were the first to realize that, as the physicists say, the flexibility of glass is a function of its diameter.

Venetian glass became famous all over Europe. The secrets of its manufacture were jealously guarded by the Venetian craftsmen.

Glass Warp, Silk Fill

In 1893 Edward D. Libbey, of the Libbey Glass Company, succeeded in drawing from the heated ends of glass rods, coarse fibers of glass which were wound on large revolving drums. The fibers were worked together with silk threads, into a fabric that was made into lampshades. The lampshades were shown at the Columbian Exposition in Chicago.

There a celebrated actress saw them and arranged to have a dress made of the same fabric. So fascinating was the idea of a glass dress that Princess Eulalie of Spain determined that she, too, must have one. Her glass dress is said to have been valued at $30,000.

But these fibers of glass were not sufficiently flexible. Nor was the fabric entirely of glass. Glass was the warp, silk the fill. The fabric was of no practical value, since it could not be folded without splitting.

In the early 1900's a number of patents were issued in Germany, and some in England, on various processes for drawing finer fibers of glass. The fibers produced were still too coarse for use in weaving practical fabrics, but they were used to some extent as thermal (heat and cold) insulation, particularly in Germany during the period of the First World War.

Owens-Illinois and Corning

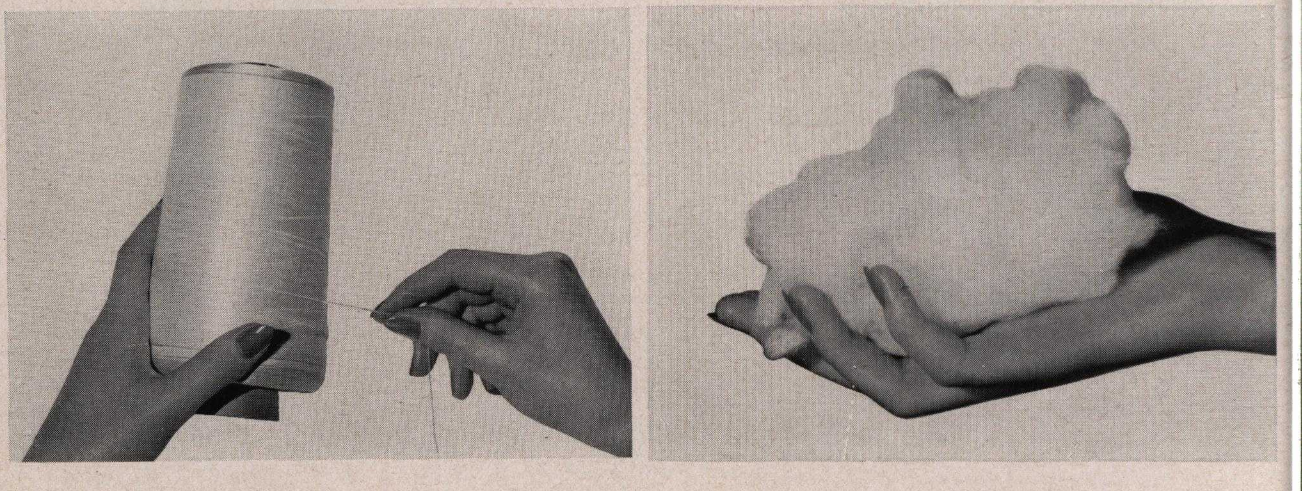
The real start toward what today we call Fiberglas was made in 1931. In that year research aimed at the development of processes for producing more pliable and more commercially useful glass fibers was initiated in this country by Owens-Illinois Glass Company, the nation's most progressive glass container manufacturer, and by Corning Glass Works, manufacturer of glass specialties ranging from light bulbs to laboratory glassware and giant telescope mirrors.

From 1931 to 1938 Owens-Illinois and Corning spent millions of dollars on the experimental and development work required to create the manufacturing processes and acquire the knowledge needed not only to produce glass in commercially useful fiber form, but to make practical its production on a commercial scale.

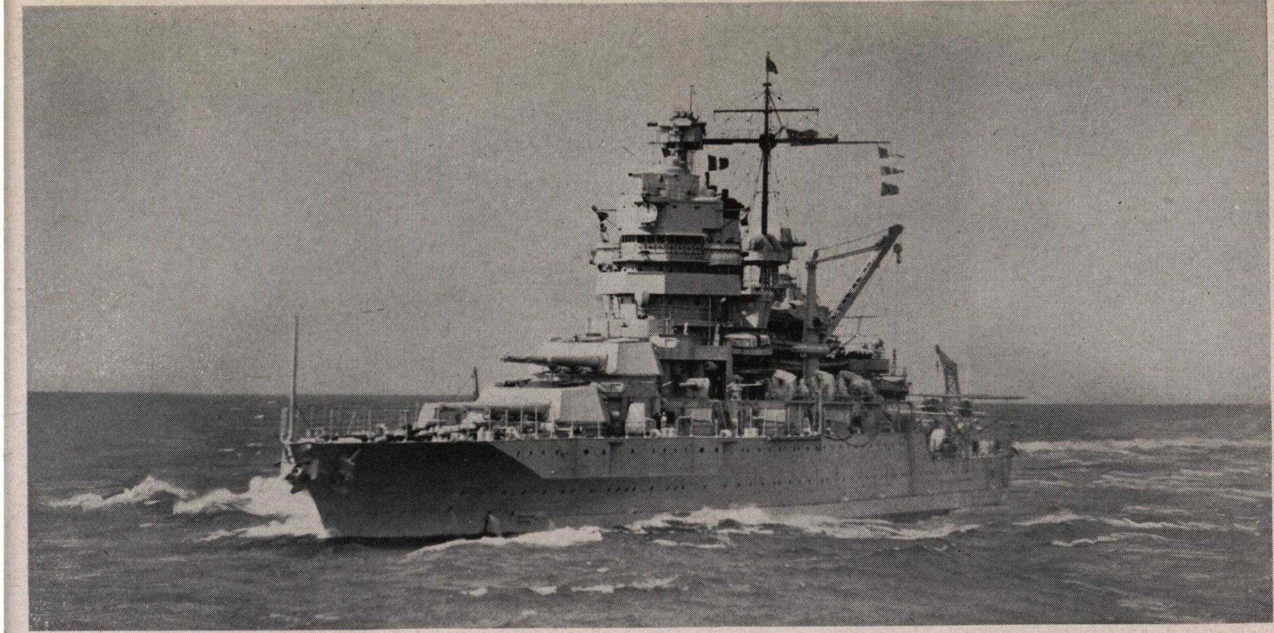
Owens-Illinois, with its headquarters in Toledo, Ohio, carried on its research in Newark, Ohio. Corning worked separately on glass formulas and related problems in laboratories and a pilot plant at Corning, New York. Rapid progress was made, both in improved manufacturing processes and in developing markets.

Relatively coarse glass fibers, coated with an adhesive, proved their value as an air filter. In the field of thermal insulation, finer glass fibers—Fiberglas in wool-like form—made steady gains. Still finer and stronger fibers were produced, and by 1936 it was possible to manufacture fibers pliable enough to be woven into all-glass fabrics that could be creased and folded.

With this milestone of progress reached and passed, new uses and new markets in the fields of electrical insulation and decorative fabrics were developed in quick succession.



A spool of Fiberglas yarn and Fiberglas in wool-like form.



Ships of the United States Navy are insulated with lightweight Fiberglas.

Owens-Corning Fiberglas is Born... *and Goes to War*

LATE in 1938 Owens-Corning Fiberglas Corporation was formed to continue the manufacture of glass fiber materials, to carry on further research, to explore additional new uses, and to adapt the materials to still other uses which their inherent properties make them uniquely qualified to serve.

The new company acquired all the assets that Owens-Illinois and Corning had devoted to the development and manufacture of Fiberglas, and the two latter companies accepted stock of the new company in exchange.

This was less than a year before the Nazi armies swept into Poland and plunged the world into war. It was a little more than a year and a half before the fall of France, and the start of the United States re-armament program. It was a little more than three years before the Japanese attack on Pearl Harbor.

Few companies, within the first few years after birth, have had to adapt outlook, production, and plans for the future, more quickly to such swiftly changing conditions.

Basic in War and Peace

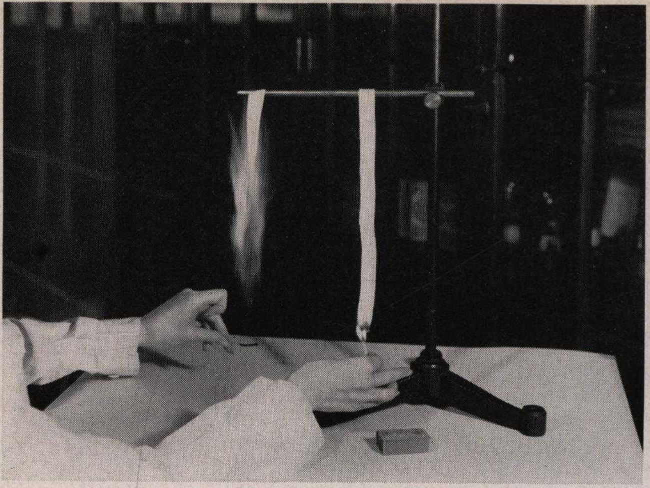
Owens-Corning was organized to meet the needs of a peace economy. On the occasion of its second anniversary the company's basic policy was set forth in the following terms:

> Certain considerations set the directions for our development and for the applications of Fiberglas.
>
> Either our materials must do a job that no other material can do effectively or adequately.
>
> Or for the same price they must perform better than other materials.
>
> Or at a lower cost they must do as good a job as alternative materials.
>
> Or their unique characteristics must enable the manufacturer using Fiberglas to make corollary savings not possible with other materials.

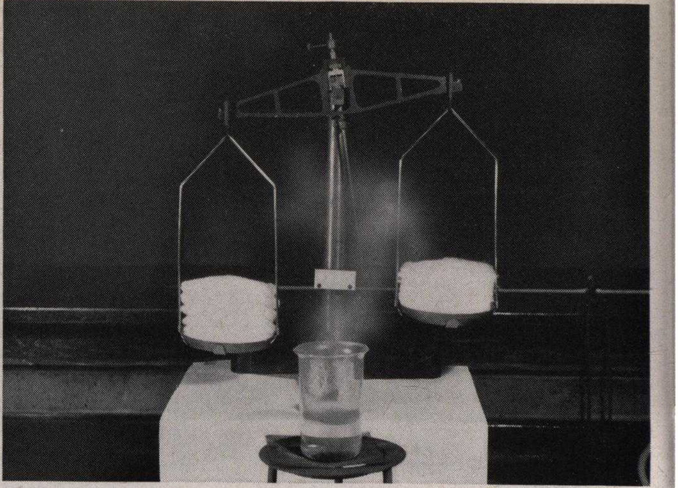
As the war spread around the globe, approaching nearer and nearer to our shores, the men responsible for the management of the Fiberglas Corporation were confronted with weighty decisions. The company itself was young; the material was young; the veterans of the Fiberglas organization were young men. With only peacetime experience to guide them, they had to appraise the properties of Fiberglas that would make it of basic importance to a nation arming for defense.

On the basis of this appraisal . . . before the actual need arose . . . without calling on the government for financial assistance . . . without any record of use to justify the investment . . . they sought and obtained "seed money" to invest in the creation of facilities to meet the needs that they foresaw as the nation gradually shifted from a peace to a war economy.

Long before Pearl Harbor, conversion to production for defense—and, if need be, for war—was well under way. Production of the factories at Newark, Ohio, was stepped up. In June, 1941, a new plant was opened at Ashton, Rhode Island. As early as January, 1941, a predominant share of the company's greatly expanded production was earmarked for the requirements of the armed forces.



Organic fibers are inflammable, but Fiberglas is inorganic and incombustible.



Organic fibers (left) and Fiberglas (right) weigh the same when bone dry. Organic fibers gain weight through absorbing moisture, Fiberglas fibers do not.

War Makes Exacting Demands

IN war, as in peace, Fiberglas can perform a needed, and in many cases a unique service wherever heat is conserved, controlled or excluded; wherever fabrics are required to withstand heat, damp or decay; wherever electricity is generated, transmitted or used; wherever air is cleaned or conditioned.

In all of these fields Fiberglas had established itself before the war. It is not a "War Baby." The war, however, has made efficient performance in these fields more vital than ever before. It has created new, more exacting demands upon the materials employed.

The ability of Fiberglas to meet these demands is due to its inherent properties which were quickly recognized by alert engineers of the armed forces. Their specifications were skillfully carried out by manufacturers who employ Fiberglas in their products.

The Properties of Fiberglas

Flexibility is the distinguishing property of Fiberglas which everyone can feel and see. Fiberglas is flexible for just one reason. The fibers are almost incredibly thin in relation to their length.

Steel is rigid in a thick, short piece, but heat it and draw it out into a fine wire and it becomes extremely flexible. The same is true of glass.

Fiberglas textile fibers are so thin that they are almost invisible. From one hundred to several hundred fibers, or filaments, are gathered together to form even a fine strand. When such a strand is folded or knotted it is unlikely that any single fiber will be bent more sharply than it can tolerate without breaking.

But flexibility is far from being the whole story. Incombustibility is another property of Fiberglas that anyone can test for himself. Light a match to a strand of Fiberglas fibers and it will not flame up, or even smolder.

The fibers may sinter or melt, and the match flame will leave a black deposit of carbon—but the material will not burn, nor will it give off smoke or any noxious gas. In textiles, fire-safety is a rare quality. It opens up to Fiberglas many fields that other materials cannot enter.

Highest Strength-Weight Ratio

Steel is the material usually chosen as the symbol of strength, but Fiberglas fibers possess the greatest tensile strength-weight ratio of any commercial material either occurring in nature or synthesized by man. Fibers averaging 23 one-hundred-thousandths of an inch in diameter have a tensile strength of more than 250,000 lbs. per square inch.

No Shrinkage or Stretch

Glass fibers, even though as fine as gossamer, are still neither more nor less than microscopically tiny glass rods. Because they have no cellular interstructure, they cannot absorb moisture. Their surfaces can be wet, but moisture cannot get into the individual fibers.

Moisture, therefore, will not cause the fibers to shrink, stretch or swell. They will not rust, rot or mildew. They are unaffected by most acids. When used with suitable varnishes, and skillfully applied by electrical design engineers, they offer high resistance to the flow of electric current.

Light As Aluminum

Solid glass is as light in weight as cast aluminum. A cubic foot of glass in the wool fiber form is approximately one hundred times lighter than a cubic foot of solid glass. Fiberglas insulating wool weighs only one and a half pounds per cubic foot and is actually 99 per cent air and 1 per cent glass.

This light weight, combined with resiliency in the wool-like forms, gives great thermal insulating value per pound of glass. The textile fibers not only have great strength in proportion to weight, but occupy little space in proportion to strength, weight, or electrical insulation value.

It is the combination of all these properties in one basic material, that makes it possible for Fiberglas to better perform many services than any other one material. This advantage has also made it possible for Fiberglas to adequately replace certain materials now critically scarce because of vital war uses.

The Flow of Heat

THE word "insulation" does not in itself call up a picture of the complex problems involved in controlling the flow of heat, whether in the home, aboard ship, on a plane, or in an industrial plant.

No better illustration of the complexity of these problems can be found than is provided by the conditions encountered in the low-temperature installations used for the preservation of perishable foods, the cold-processing of many war materials, and the testing of military equipment. Here the outside temperature may be from 100 to 120 degrees, Fahrenheit, while the temperature in the cold compartment may be far below zero. Wherever a temperature differential exists, Nature makes every effort to destroy it by causing the heat to flow toward the cold until inside and outside temperatures are the same.

But Nature doesn't rest content with this. Where there are large temperature differentials there is usually also a great difference in the amount of water vapor in the warm and cold air. The warmer the air, the greater its moisture capacity.

Just as heat always tries to flow toward cold, so heavy concentrations of moisture try to dilute themselves in the colder air that contains less moisture. Thus Nature tries to force both heat

Fiberglas - insulated portable shelters for Army Air Forces personnel save fuel in Arctic climates.

Navy use of Fiberglas saves aluminum formerly used for interior sheathing on fighting ships.

and moisture through the insulation barrier into the cold compartment—or through the wall of a heated home to the cold outside atmosphere.

If the attempt succeeds, and moisture enters the insulation through the warm side, but is unable to get out through the cold side, it overloads the air near the cold surface and condenses into water. If this happens the effectiveness of the insulation is impaired, because water is an excellent conductor of heat.

Further, when the vapor condenses on a surface that has a temperature below 32 degrees, Fahrenheit, it freezes, swells, and may even exert enough force to break down the construction that contains the insulation.

Engineers know how to retard the flow of moisture into insulation from the warm side, and how to prevent condensation by allowing moisture to escape through the cold side, but it is not always possible to provide sufficient safeguards against the forces of Nature. Heat and moisture vapor, for instance, will flow through materials that will stop the flow of air or water.

The degree to which the insulation material is able to withstand such destructive moisture conditions, while retarding the flow of heat from the warm to the cold surface, is the test of its efficiency.

Fiberglas Meets Test

When glass fibers are interlaced to form a resilient, wool-like mass, or when the fibers are treated with a binder and compressed into boards, millions of air spaces are entrapped. These air spaces retard the flow of heat. Where the fine, cylindrical fibers cross and touch each other they have exceedingly small contact points. Heat, therefore, cannot pass readily from one fiber to another.

Add to this the fact that the individual fibers will not burn . . . that they will not absorb moisture . . . that if they become wet they will not rot or mildew . . . that they will not settle under vibration . . . that individually and in the mass they are extremely light in weight . . . and you have the chief reasons why Fiberglas is one of the most efficient and widely used thermal insulating materials.

Fiberglas on Navy Ships

Before Pearl Harbor, Fiberglas was employed to control the flow of heat in household refrigerators, ranges and water heaters; in dwellings and other buildings, including industrial plants; in ships, planes, buses and trains. So far as the civilian market is concerned, many of these applications are discontinued for the duration, but practically all of them find their counterparts in production for war.

One of the most important properties required of materials used in the construction of United States Navy ships is incombustibility, or fire safety. This requirement is met by Fiberglas. As early as 1932, shortly after the first Fiberglas thermal insulation was produced, it was installed in several Navy ships on horizontal surfaces.

The insulation performed so efficiently that it was adopted for all horizontal surfaces in living spaces and magazines, and for all spaces in refrigerators, in all fighting craft designed after 1935. In 1939 the Navy adopted glass fiber material as thermal insulation throughout all its fighting ships.

Aluminum Saved

When, after the United States entered the war, it became necessary to conserve aluminum and other light-weight materials, the Navy Department and the Fiberglas Corporation worked together to develop a glass fiber board faced with Fiberglas cloth, which is used for both thermal insulation and interior finish on the Navy's fighting ships. Millions of pounds of aluminum, formerly required for interior sheathing, have been saved by the use of this material.

While the Navy was increasing its use of Fiberglas thermal insulation, use of the same materials spread to the Merchant Marine. Six months after the United States declared war on the Axis powers, 75 shipyards were using Fiberglas to insulate living spaces, refrigerated spaces, magazines, bulkheads, pipes, ventilating ducts, castings and boiler uptakes.

Fiberglas in Arctic Shelters

The Army ground and air forces use Fiberglas as thermal insulation in cantonment buildings, portable shelters, refrigerators, portable food and water containers, and ammunition trucks.

Portable shelters for use by Army air force personnel in Arctic climates—sufficiently light and compact to be transported by air—employ Fiberglas in walls, and sometimes in the flooring, to cut the amount of fuel required to maintain livable temperatures. The Fiberglas in a typical shelter weighs only about 200 pounds, but it saves over 20,000 pounds in the weight of the fuel that must be transported for each shelter during the heating season.

Meets Aviation's Requirements

As thermal insulation for the hulls and cabins of both Army and Navy planes, Fiberglas meets aviation's basic requirements—non-inflammability, light weight, and low moisture pick-up.

A fire is about the worst thing that can happen to a plane flying at a speed of hundreds of miles an hour, thousands of feet above the ground. The swift passage of the plane through the air fans the flames. Means of fighting fire are limited at best, and in combat men can ill be spared to handle the fire-fighting equipment.

Yet fire is a constant hazard. Always there is the chance that an enemy machine gun bullet will strike one of the ammunition cans and scatter incendiary material through the plane. The intense heat generated by the impact of a high-velocity shell is likely to ignite anything inflammable. Fiberglas is not inflammable and provides fire with nothing to feed upon.

Low Moisture Pick-up

The moisture content of the air varies greatly at different altitudes and in different regions. If the material used for insulation picks up moisture it may add hundreds of pounds to the weight of a plane flying through humid atmospheres. The added weight decreases speed, increases fuel consumption, and decreases the maneuverability of the plane.

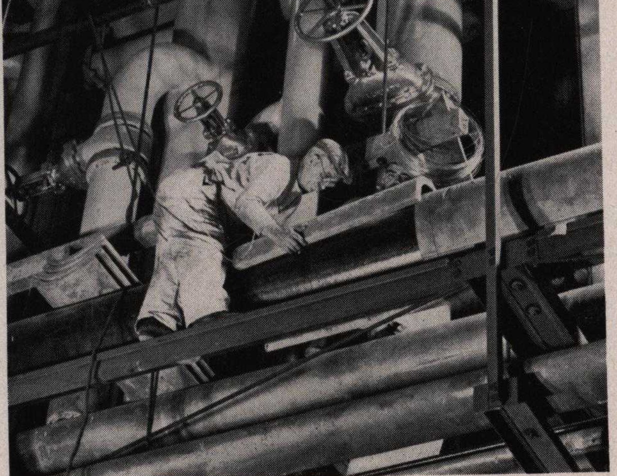
Fiberglas has a remarkably low moisture pick-up and is itself extremely light in weight. Because the individual fibers will not absorb moisture, the insulation dries out quickly if it does become wet, and moisture has no harmful effects upon it.

War Plants' Arteries

In scores of war plants, Fiberglas is installed in the walls and roofs to help maintain—summer and winter—inside temperatures that promote working efficiency. In these and other plants, Fiberglas insulates miles of piping through which flow gas, steam, water, oil and other fluids.

Such pipe lines are the arteries of a plant. Their efficient functioning is as essential to the operation of the plant as is the circulation of the blood to the human system. In a huge ordnance plant in the Middle West more than 1,000,000 linear feet of Fiberglas insulates the maze of pipe lines.

Installing Fiberglas insulation in roof of a war plant.



Insulating an industrial plant pipe line with Fiberglas.

Fiberglas electrical insulation in war planes resists moisture, helps assure quick take-off.

Fiberglas in Plane Plants

One of the factors that makes Fiberglas an efficient barrier to heat transfer—the millions of air spaces imprisoned in the material — makes it an equally efficient sound absorbing material. In planes, and in the walls and roofs of war production plants, it is frequently used for both of these purposes.

A notable example of the use of Fiberglas for sound absorption as well as thermal insulation is provided by several huge plane assembly plants. The length of the main building of each of these plants is greater than the combined lengths of the four largest ocean liners ever built. Designed as complete blackout plants they are noise conditioned, light conditioned, air conditioned and fire-proof.

Millions of board feet of Fiberglas are installed in the walls and roofs to control heat transfer and to absorb up to 80 per cent of the noise created by production processes—noise that saps energy and slows production.

Fiberglas in Sound Stacks

The testing of airplane engines presents a difficult noise problem. One engine under test creates a deafening racket. A dozen under test at the same time create an ear-splitting inferno. To prevent deafness among workers, to prevent residents in the neighborhood from going mad, means must be found to deaden the tremendous volume of sound.

The sound absorbing material must be able to withstand the effects of lubricating oils, gasoline and water vapor, and of terrific wind velocities generated by the engine propellers. In sound stacks at air fields throughout the United States, the sound absorbing material is Fiberglas, installed in the form of blankets between perforated metal sheets.

Fighting Fabrics

BEFORE the war, Fiberglas textile fibers, twisted and plied into yarns, were used for weaving tapes, braids and cloths employed for electrical insulation—and for weaving decorative fabrics that would not shrink or stretch, burn, mildew or decay.

Fiberglas electrical insulation has become vital to the whole war program, and yarns formerly woven into Fiberglas decorative fabrics have been diverted to war uses.

Parachute Flare Shields

Because of its ability to withstand intense heat, and because it is light in weight, Fiberglas cloth is used as a shield for the brilliant magnesium parachute flares of about 1,000,000 candle power which are employed by the Army Air Forces to illuminate the objective of a bombing attack. If the light of the flare were not shielded overhead, bombardiers would not be able to see the ground because of the glare, and attacking planes would be revealed to enemy anti-aircraft gunners.

Fiberglas tapes are used to wrap, or lag, insulated piping on Navy ships, to wrap exhaust pipes on planes, and in other "hot" applications where canvas could not stand the high temperatures or where asbestos fabrics would be too heavy and bulky. Fiberglas cloths are used as filters in processing many chemicals. To save weight and critical metals, the Navy and Merchant Marine are using Fiberglas curtains to replace doors below decks.

Navy Diving Suits

In electrically heated diving suits worn by Navy divers to enable them to stand the paralyzing cold encountered at great depths, the wires carrying the current are enclosed between layers of Fiberglas cloth. Fiberglas—incombustible and heat resistant—is used so that if a wire should break and the current jump the gap, the spark will not ignite any combustible material . . . which would burn fiercely in the helium-oxygen gas now widely used in diving operations instead of compressed air.

Wafer-like mats of Fiberglas like those that add to the life and stamina of storage batteries in passenger cars and trucks give longer life and greater power to the storage batteries on which submarines operate, and to the batteries in Army tanks, trucks and jeeps. The mats hold in place the power-producing material which tends to shed off under hard usage and heavy vibration.

Wire netting, "garnished" with Fiberglas fibers, and painted to blend with the terrain, is used to camouflage possible bombing objectives in seacoast areas where a material resistant to salt air and dampness is required.

Electrical Insulation

The value of Fiberglas electrical insulation in the war program lies primarily in its resistance to the forces that are always at work seeking to break down the insulation. Chief of these are high temperatures and moisture.

Within broad limits, the amount of heat the insulation and its varnishes can bear is the chief factor in determining the temperatures at which electrical equipment can operate, the overloads it can stand, and the size and weights of the equipment that must be employed.

Planes . . . Tanks . . . Ships

Weight is a critical factor in the design of planes. Every pound of weight saved means an increase in cruising range, load capacity and maneuverability—and a decrease in fuel consumption.

Before the war, plane manufacturers were sometimes paid a bonus amounting to as much as $300.00 for every pound of weight cut from their planes. Dollars were the reward of weight saving in time of peace. In time of war, the reward is added fighting power and greater safety for the crews who man the planes.

The small space occupied by Fiberglas electrical insulations has made it possible for skillful electrical design engineers to decrease the size and weight of motors and generators used in planes, on shipboard, and in tanks. Such small, lightweight motors operate under high temperatures, high overloads, and hard usage over long periods of time.

Pitch-Change Motor

One of the tiniest, but at the same time most vital motors in a plane, is the pitch-change motor. Hidden in the propeller assemblies, these motors must be small enough to fit in the restricted space, but powerful enough to change the pitch of propellers that have gone dead, so that the blades are turned edgewise to the wind.

Otherwise the propellers on dead engines would windmill, setting up a racking vibration that would soon shake the plane to pieces. These little motors are insulated with Fiberglas.

Aids Quick Take-Off

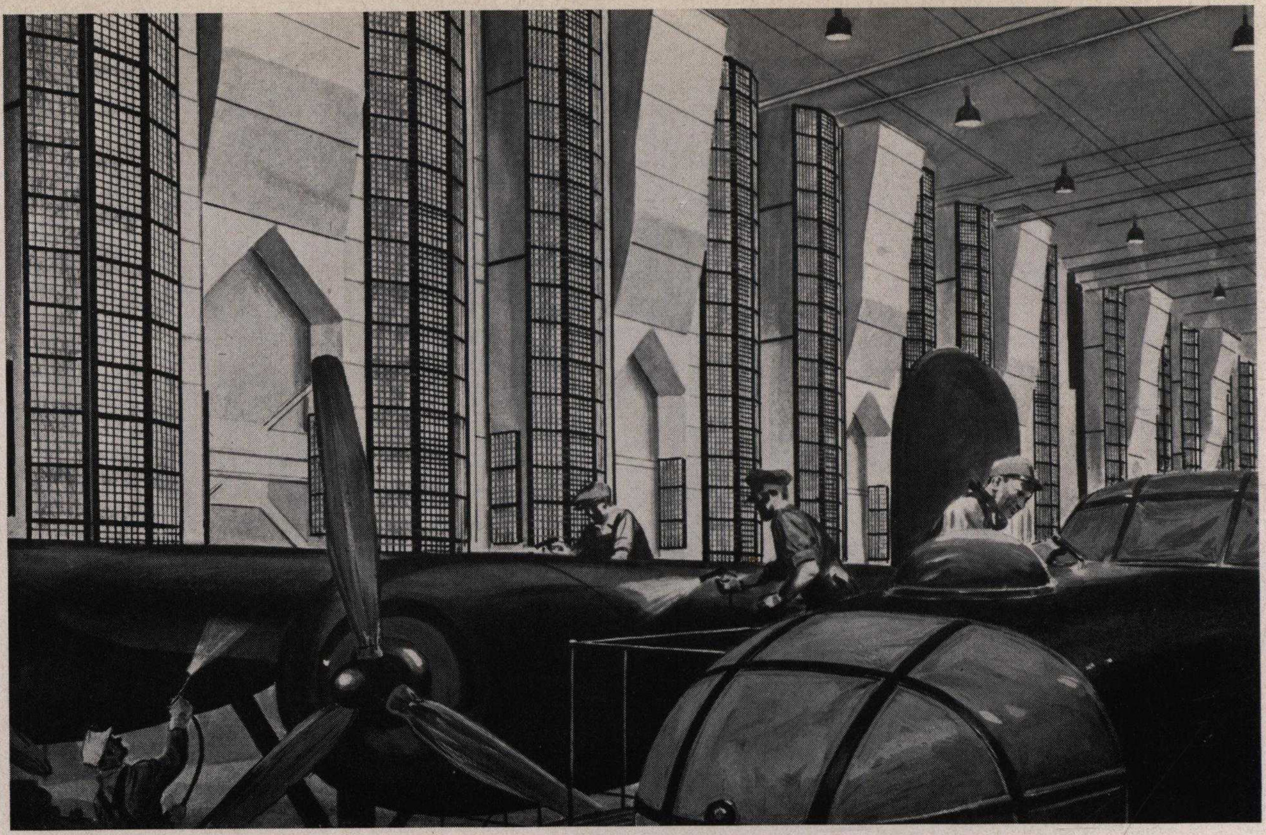
Whenever and wherever humidity is high, electrical insulation is subject to the danger of moisture penetration. Moisture can so foul the electrical system of a fighter or bomber plane as to prevent a quick take-off.

Using Fiberglas, an ignition cable has been developed which helps to assure a quick take-off even when the plane has been subjected to severe and prolonged humidity conditions. Because Fiberglas resists intense heat, and will not support fungus growth, approximately 85 per cent of all radio hook-up wire for aircraft transmitters and receivers is Fiberglas insulated.

Navy Deck Motors

Navy deck motors are equipped with Fiberglas insulation, primarily because of its resistance to moisture. Propulsion equipment on Navy ships is largely Fiberglas insulated because of the reliability and stamina under severe overload conditions that can be built into such units by using glass and suitable varnishes.

Several types of heat and flame-resistant Navy cables have been developed around Fiberglas insulation. Armored cables have been lightened, and the use of metal reduced, by wrappings of Fiberglas barrier tapes.



Fiberglas filters clean the air entering paint-spray buildings of mammoth bomber plants.

Dust...A Saboteur

IN the early 1930's manufacturers of warm air heating furnaces equipped with a blower, and manufacturers of air conditioning and ventilating equipment, were confronted with a common problem—how to move large volumes of air without moving dust and dirt along with it.

Replaceable Fiberglas Dust-Stop air filters, composed of glass fibers coated with a dust-catching adhesive, were introduced at the convention of the National Warm Air Heating Association, in1932. They excited some interest, but no great stir. Many were skeptical of their practicality.

Clean Air For War Plants

Today Fiberglas Dust-Stop air filters are standard equipment in thousands of domestic forced-warm-air heating systems, and for the great majority of central and room air conditioning and ventilating systems in the commercial and industrial field.

In war plants, Fiberglas filters remove from the air tiny particles of dust that could ruin the accuracy of our gun and bomb sights, shorten the life of engines and motors, or cause catastrophic explosions. In telephone exchanges, they clean the air of dust that could seriously impair the efficiency of one of our vital communications systems.

Dust is recognized by industry as a saboteur that works tirelessly to slow the output of war materials and impair their quality. No organization of human fifth columnists could do a more complete wrecking job.

Collects Explosive Dusts

Among the largest installations of Fiberglas air filters are those in the paint spray buildings of two mammoth bomber assembly plants in the Southwest. Three thousand six hundred and forty-eight filters are employed to strain the dust from the air entering each of these buildings.

In ordnance plants, similar glass fiber filters are employed to collect from the air particles of TNT and other explosive dusts created by the manufacturing operations. If allowed to accumulate on the walls, floors or machines, the particles would eventually create a hazard that could result in great loss of life and wreckage of the plants.

The efficient operation of the nation's automatic telephone exchanges is contingent upon the establishment of close contacts between small metal parts. If dust accumulates on these parts it acts as an insulator, and can cause static that interferes with conversation, an epidemic of wrong numbers, or complete failure to operate.

Eliminate Health Hazard

In scores of plants manufacturing precision instruments and machine parts, Fiberglas filters are employed to collect dusts created by grinding processes, eliminating a hazard to the products being manufactured and to the health of workers in the plant.

If dust enters the carburetor of an internal combustion engine during operation, it works its way into the lubrication system where it acts as an abrasive to shorten the life of the motor. Planes, tanks, trucks and other military equipment have been equipped with Fiberglas air filters to prevent the admission of abrasive dusts.

War Weapon to Save Lives

FIBERGLAS is a small but vital element in a new and almost miraculously effective war weapon to save lives. From all the battle fronts comes word that blood plasma transfusions are proving to be one of the greatest single factors in reducing the number of wounded who succumb to their wounds in this, as compared to other wars.

A tiny strip of tape, woven of glass fibers, is employed as a filter in the tubing of the light, portable apparatus used to give transfusions—frequently just behind the front lines. Through this strip of Fiberglas tape the fluid passes from the plasma bottle to the wounded man's veins.

The Fiberglas tape is used as the filter because the tape can be sterilized for repeated use, because it requires no bulky housing, because the weave is close enough to strain out any undissolved particles the fluid may contain, and because, being glass, the fibers do not swell when wet, thus offering no impediment to the free passage of the fluid.

Sutures and Sponges

Surgeons are experimenting with the use of Fiberglas thread as a surgical suture which, because it is non-absorbent and does not irritate the tissues, does not encourage the formation of fluids that would harbor germ life. Strands of radio-opaque Fiberglas yarn have been incorporated in surgical sponges so that if a sponge is inadvertently left in the wound, it may be detected by the X-ray.

Surgical uses of Fiberglas could never account for more than a tiny fraction of the output of the Fiberglas factories, but they represent actual or potential humanitarian uses of glass in fiber or filament form.

On the battlefield, Fiberglas filters the blood plasma before it enters the wounded man's veins.

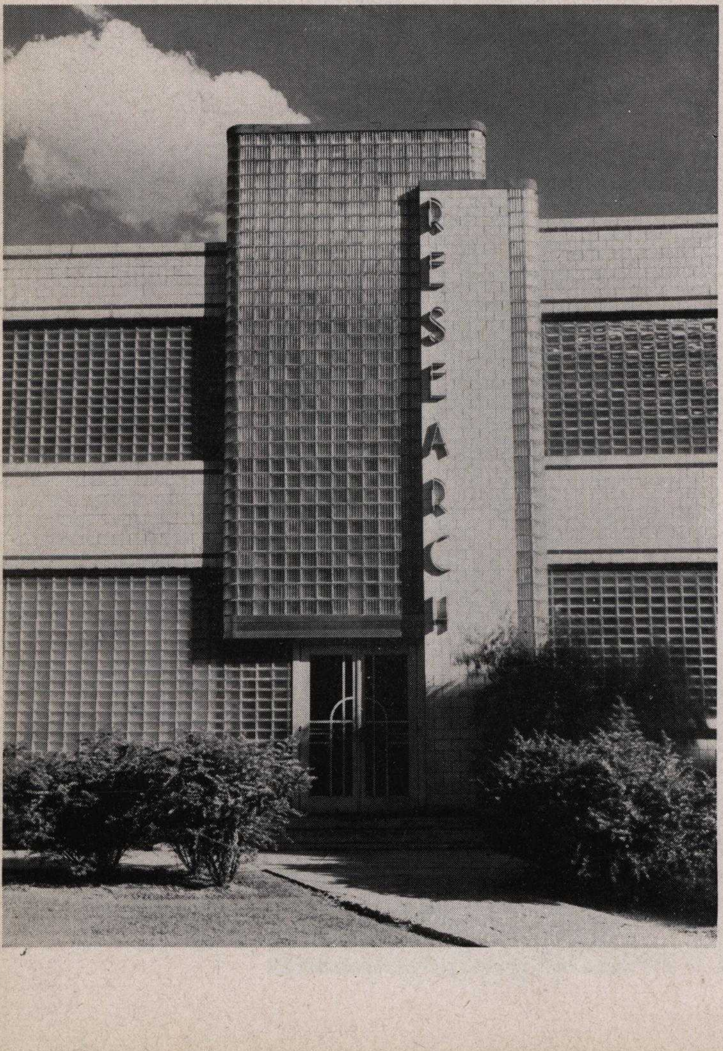
Fiberglas Research

FIBERGLAS was born of industrial research. From the time of its birth research has been depended upon to make it possible to produce finer and stronger fibers, to develop new uses for Fiberglas materials, to adapt the materials to meet needs that cannot be adequately met by other materials, and, finally, to produce progressively better materials that can be sold at progressively lower prices.

Design Own Machines

One important phase of Fiberglas research has been directed towards the design and constant improvement of the machines required to make glass fibers. Many manufacturers can buy all, or practically all, their machines ready made; or they can have them made by outside plants. The Fiberglas Corporation cannot, and never could.

Until they were invented by Fiberglas engineers, no such machines had ever existed. The Fiberglas organization had to design them, build them, improve them, re-build them, and improve them again. The process still continues. Fiberglas still designs, builds and improves its fiber forming machines.



Surface Expansion

For a great many years a great many people have known how to make good glass—but not glass of a kind that can be produced in the form of strong, durable and almost infinitely fine fibers. To mention only one factor, expansion of surface area presented a problem that only skilled and patient research could solve.

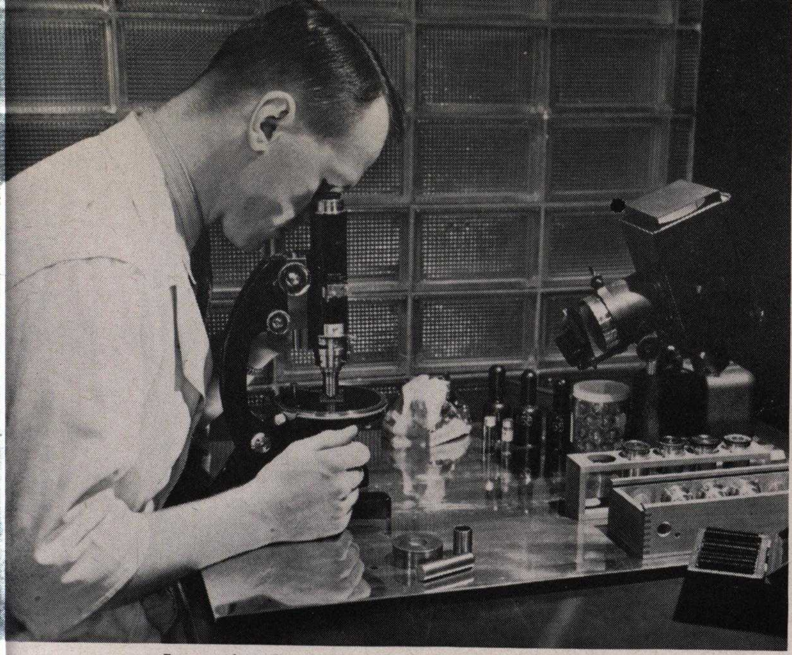
Because glass does not rust, and is able to withstand surface attacks of many acids and mild alkalies without any apparent harm, most people assume that, aside from breakage, glass is practically indestructible. But the glass chemist knows that some glasses are more durable than others, and that surface attacks do have an effect on most commercial grades of glass. The greater the surface area, the greater is the opportunity for these attacks to occur.

When a given mass of glass is drawn into fine fibers its surface area is increased many times. For this and other reasons it is necessary to develop special glass formulas as one step towards providing the fine glass fibers with resistance to weathering, chemical action and other influences to which they will be exposed. No single formula will solve the problem, since the properties the fibers must possess differ with the uses in which they will be employed.

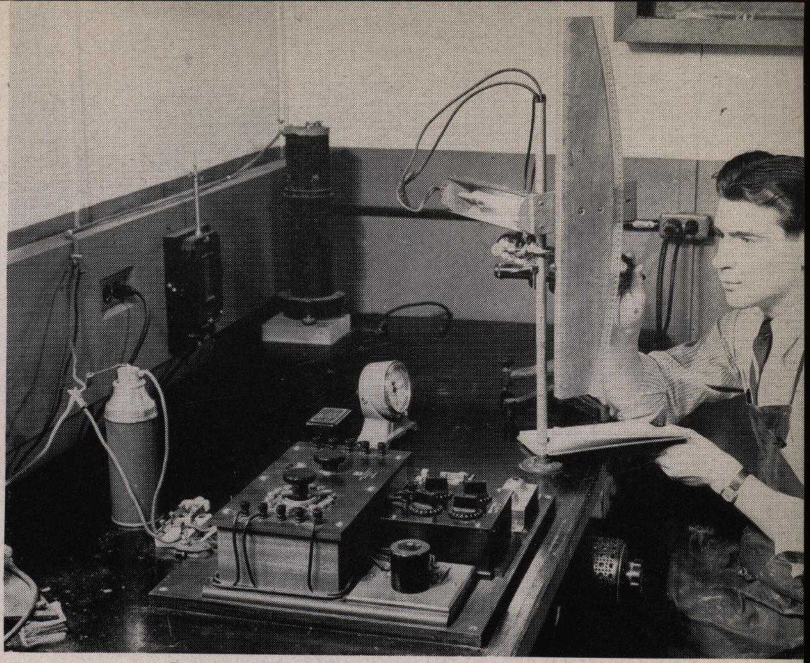
Other Laboratories Aid

Fiberglas research is not confined to the company's own laboratories. Many problems involved in the development and testing of materials are regularly referred to independent testing and university laboratories in order to bring fresh viewpoints to bear. The laboratories of other manufacturers, too, have done a superb job in adapting Fiberglas materials to their particular needs, thus constantly broadening their fields of use.

Today all Fiberglas research is devoted to increasing the output of materials for the armed forces, and to developing Fiberglas materials which it is believed will aid the Army and Navy in solving problems imposed by the growing demands of total war. Fibers have been produced experimentally that show tensile strengths exceeding 1,000,000 pounds per square inch. Experimental fabrics have been produced that will stand temperatures of nearly 2000 degrees, Fahrenheit.

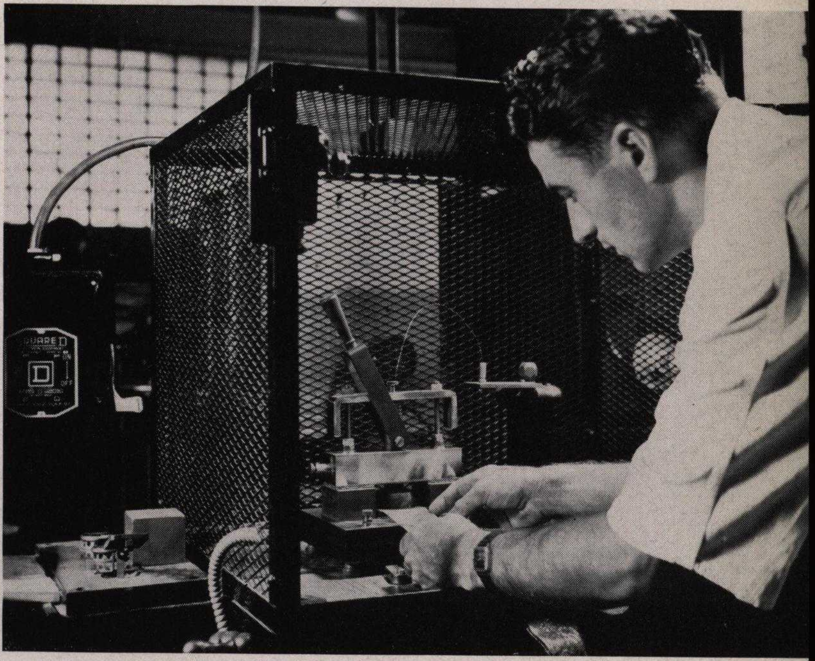


Inspecting glass with a petrographic microscope.



Determining the softening temperature of glass.

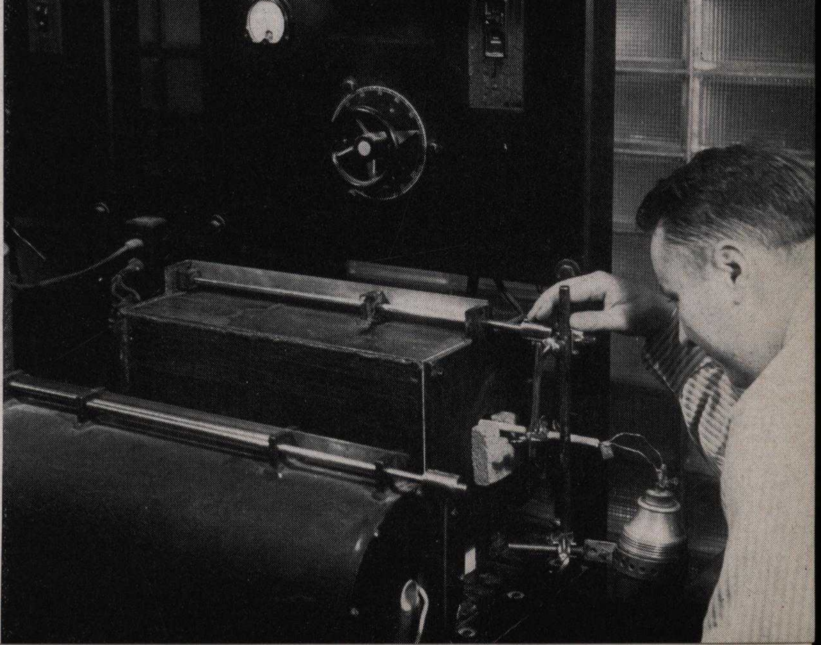
Testing resistance to alkalies and chemicals.



Measuring dielectric strength of Fiberglas tape.

Measuring fiber diameters magnified 2000 times.

Checking devitrification temperature of glass.



Manufacturing Processes

THE first step in the manufacture of Fiberglas is the selection, mixing and melting of the raw materials—selected sands, limestone and other mineral ingredients.

By varying the ingredients and their proportions—that is, by employing the right formula—by close temperature control, and by controlling the diameter of the fibers, the fibers are given the special properties they must have to perform the service for which they are designed.

Two Basic Types

There are two basic types of Fiberglas fibers:

Fibers which are interlaced in a resilient wool-like mass for fabrication into bats, blankets, boards and other forms.

Fibers which are twisted and plied into yarns which, in turn, are woven into braids, tapes and cloths.

In manufacturing the first type of fibers, the raw materials are melted and refined in large furnaces holding 40 tons or more. The molten glass flows from the furnaces in thin streams. Jets of high-pressure steam hit these streams of glass with terrific force and yank them into threadlike fibers.

The fibers fall upon a conveyor belt, in a fleecy, resilient mass. For some thermal insulation applications, Fiberglas is used in this form. For other thermal applications it may be treated with a binder, compressed, and shaped into rigid or semi-rigid boards.

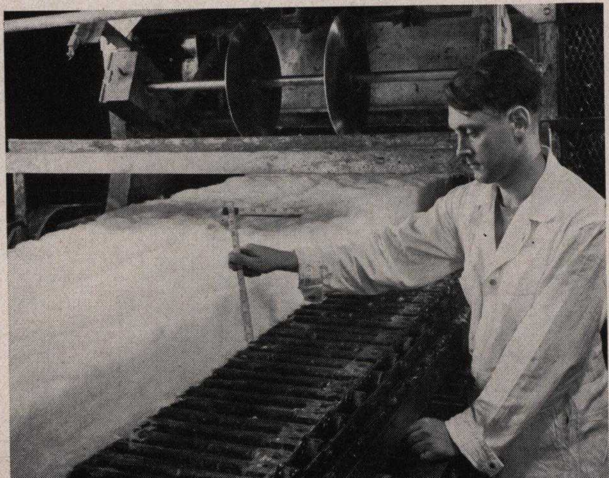
Two Textile Processes

In the manufacture of the textile fibers two processes are employed—the continuous filament process and the staple fiber process. Both processes require that the raw materials be melted and refined, and that the glass then be molded into marbles about five-eighths of an inch in diameter.

The marbles are carefully inspected for impurities that might affect the tensile strength or other properties of the fibers. Those that pass the inspection are remelted in small electric furnaces, each of which has many small holes in the base of the melting chamber through which the molten glass flows in fine streams, or filaments.

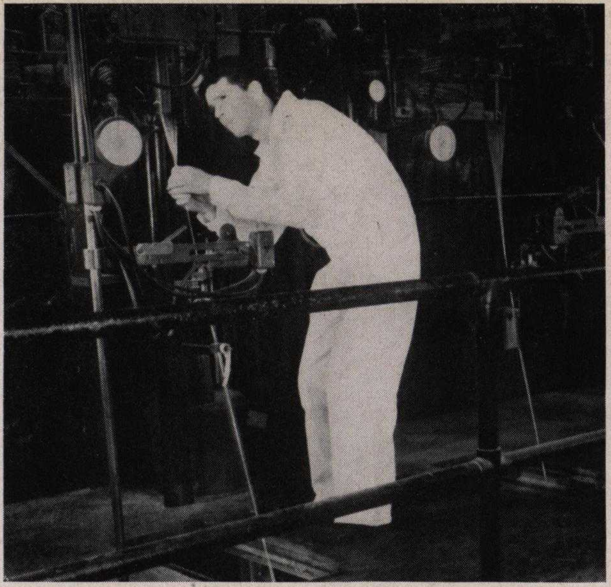
Continuous Filament Process

In the continuous filament process, more than 100 filaments are drawn simultaneously and gathered into a strand. The strand is attached to a high-speed winder that, as it draws the strand, attenuates each stream of glass where it emerges from the



The fibers form upon the conveyor belt in a fleecy, wool-like resilient mass.

The marbles are inspected for impurities that might affect fiber properties.



Before Pearl Harbor, men tended the machines which form continuous filaments and gather them into a strand.

Today the majority of the forming machines are tended by women trained to take the place of men.

furnace, reducing its diameter to a fraction of the diameter of the hole through which it emerges.

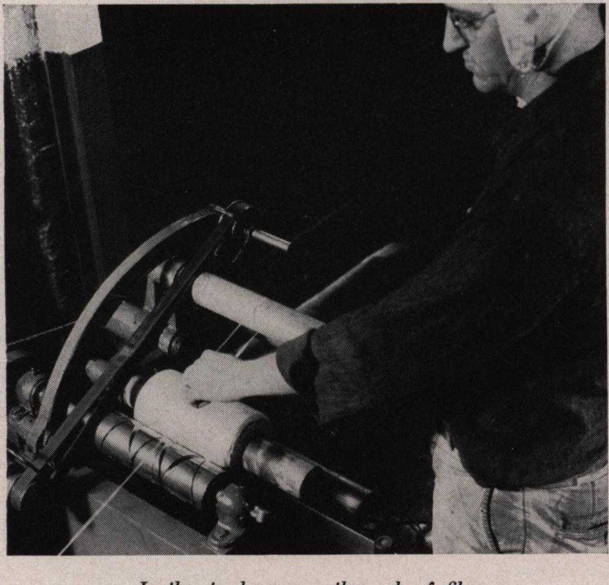
From a single marble, 97 miles of a single filament can be drawn. The length of the continuous filament strands is limited only by packaging requirements. The strands could be drawn to indefinite lengths, running to thousands of miles.

Staple Fiber Process

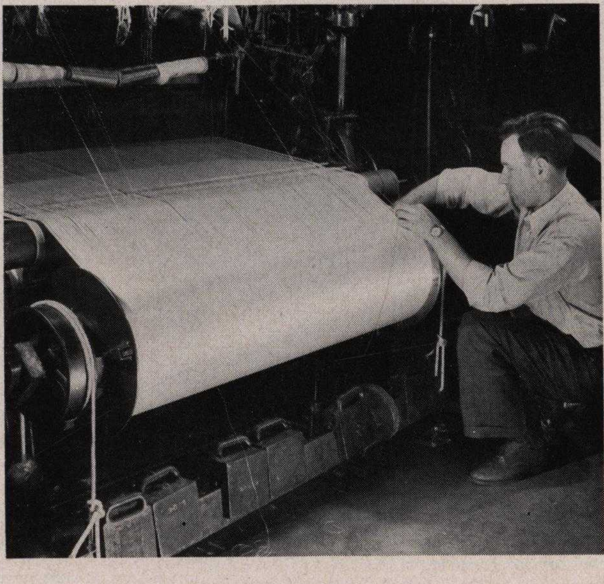
In the staple fiber process, the molten glass also flows in thin streams through small holes in the base of the furnace, and is struck by jets of high-pressure air or steam which yank the glass into fibers varying in length from 8 to 15 inches—much greater than the length of the best long-staple cotton.

The fibers are driven down onto a revolving drum on which they form a veil resembling a cobweb. The gossamer web of fibers is gathered from the drum and wound on a tube in the form of a sliver (pronounced slyver) an untwisted soft yarn.

Strands of either continuous filament or staple fibers are twisted and plied on textile machinery into yarns from which Fiberglas fabrics are woven. Fabrics woven of continuous filament yarns are thin, smooth and lustrous. Fabrics woven of staple yarns have a slightly fuzzy appearance and are less lustrous.



In the staple process the web of fibers is formed into a soft untwisted yarn.



Fiberglas yarns are made ready for weaving into fabrics on textile machinery.

Fiberglas
...and the Post-War World

TO meet the needs of the armed forces, the production of Fiberglas has been increased tremendously since the United States entered the war.

Facilities in the Ohio and Rhode Island plants have been expanded. Processes have been improved and accelerated. In the spring of 1943 a contract was signed with the Defense Plant Corporation, an RFC subsidiary, for the operation of a new Fiberglas plant in Pennsylvania.

The number of men and women in the Fiberglas plants has grown in step with rising output. So that they might learn to operate the machines in a minimum of time, and without slowing production, programs have been organized for training the increasing number of women recruited to fill the places of men leaving to join the fighting services.

War has quickened the accumulation of knowledge and experience covering the performance of Fiberglas in widely varied applications, under unusually severe service conditions. It has, however, shelved more than 300 research projects covering potential peace-time uses which cannot be completed because of the demands made by the war upon the Fiberglas research organization.

After the war this dammed-up flood of research will be released, and will be pointed to the development of new markets. War-aimed research has already shown how to combine Fiberglas with plastics to form structural materials possessing extraordinary strength in proportion to their weight. Similar combinations of Fiberglas and plastics offer the possibility of light-weight, durable furniture that can be molded, saving fabrication costs.

Boards composed of compressed glass fibers that can be sawed and fitted like lumber will provide a light-weight, fire-proof material for controlling the transfer of heat and sound in industrial buildings, making it easier to provide "controlled conditions" that increase working efficiency and production. Because of their light weight they will enable engineers to save steel by reducing the load on supporting beams and columns.

Only a start has been made in exploring the possibility of combining glass fibers with other fibers—asbestos, cotton, hemp, rayon, silk and linen—to produce fabrics possessing combinations of qualities hitherto unobtainable. Work done in this field offers prospects of new fabrics that will find many uses by industry and in the home.

One post-war certainty is that non-inflammable decorative fabrics woven of Fiberglas yarns, or of Fiberglas and other incombustible yarns, will be available in new and more beautiful colors and designs, for use in the home, in restaurants and hotels, and on shipboard.

Not a certainty, but certainly a possibility, is the use of Fiberglas fabrics for awnings for homes, hotels, restaurants and stores. For years one of the chief hazards to awnings has been the lighted cigarette tossed from an upper-floor window. Fiberglas awnings would not burn.

Fiberglas may become a factor in permanently reducing the amount of rubber required in tires. Glass cannot replace rubber, but if, as seems possible, further research results in the development of glass textile fibers suitable for tire cord, their great tensile strength and heat resistance will reduce the amount of rubber needed.

All the basic war-time uses of Fiberglas were basic peace-time uses before the war. When the Axis has been defeated they will be basic peacetime uses again. Together with the uses that will be developed with the return of peace, they assure new, broad and constantly expanding fields of service for Fiberglas in the post-war world.

FIBERGLAS

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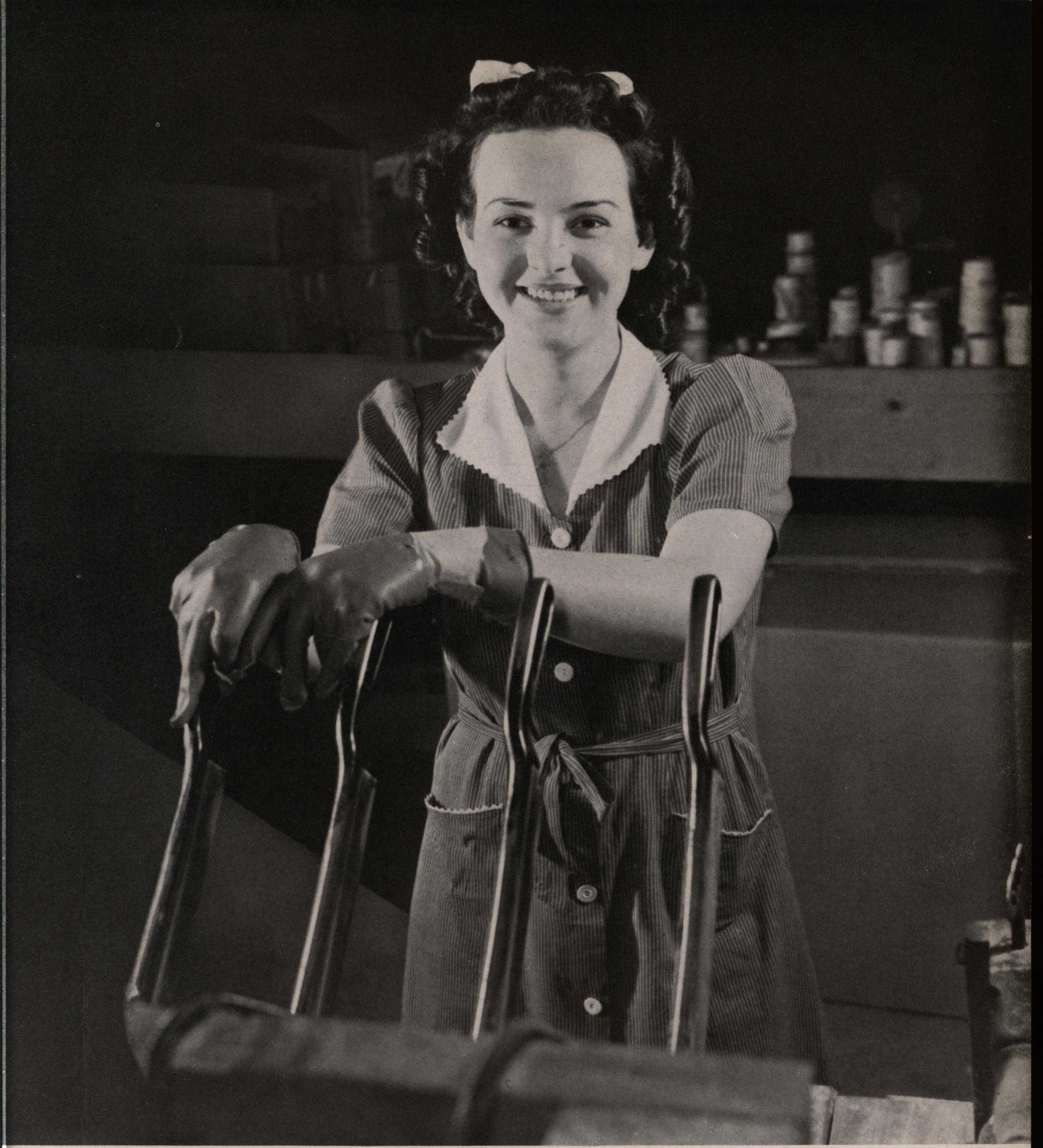

BATTERY MAT INSPECTOR—OWI PHOTO BY PALMER

Soldier of Production

Some Recent Articles and Books Describing the Development, Properties, Manufacture and Uses of Fiberglas

AMAZING CONQUESTS OF GLASS
In *Science Digest*, Vol. XIII, No. 3 (March 1943), pp. 67-70.

GLASS: NOW AND TOMORROW
In *Fortune*, Vol. XXVII, No. 3 (March 1943), pp. 122-125, 179-180, 182, 184, 186, 189.

GLASS PINCH HITS FOR THE WHOLE TEAM
By Roderick M. Grant, in *Popular Mechanics*, Vol. LXXIX, No. 2 (February 1943), pp. 50-55.

GLASS TEXTILE FABRICS FOR THE HOUSEHOLD
By Dorothy Jane Heath, in *Practical Home Economics*, Vol. XX, No. 3 (March 1942), pp. 93, 115-116.

GLASS GOES TO TOWN
By J. R. Hildebrand, in *National Geographic Magazine*, Vol. LXXX, No. 1 (January 1943), pp. 1-48.

USE OF FIBROUS GLASS BY THE ARMY AND NAVY
By Major Hubert D. Keiser in *Mining Technology* (Technical Publication No. 1598), Vol. VII, No. 3, May 1943.

FIBERGLAS: SOME PROPERTIES AND NEW APPLICATIONS
By Dr. F. V. Tooley, in *Bulletin Of The American Ceramic Society*, Vol. 22, No. 3 (March 15, 1943), pp. 60-64.

FIBERGLAS—A NEW BASIC MATERIAL
By William H. Page, in *Science Counselor*, Vol. VIII, No. 4 (December 1942), pp. 109-111, 124.

MACHINES FOR AMERICA
By Marshall Dunn and Lloyd N. Morisett, (Yonkers, N. Y.: World Book Company, 1943).

SCIENCE REMAKES OUR WORLD
By James Stockley, (New York, N. Y.: Ives Washburn, 1943).

GLASS . . . THE MIRACLE MAKER
By C. J. Phillips, (New York, N. Y.: Pitman Publishing Company, 1941).

The manufacture of fibrous glass is listed as an essential activity under Item 20 (Production of Textiles) and Item 22 (Production of Stone, Clay and Glass Products) in the War Manpower Commission's Release PM-4343, March 25, 1943. Nearly 100 per cent of all Fiberglas production is being furnished for war uses under Army, Navy, and Maritime Commission specifications. Fibrous glass textiles are listed as a critical material and are allocated to the Claimant Agencies by the War Production Board for approved end uses in accordance with Conservation Order M-282, dated February 9, 1943.

* * *

OWENS-CORNING FIBERGLAS CORPORATION, TOLEDO, OHIO

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